Paul Bergeron 3/15

THE VALUE OF ETHANOL AS FEEDSTOCK

FOR

ETBE BLENDED IN CALIFORNIA RFG

Prepared by

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The Value of Ethanol as Feedstock

for ETBE Blended in California RFG

This report describes an analysis of ethanol's value as feedstock for ETBE blended in California reformulated gasoline (RFG). The work described in this report was carried out as part of Task 2 of NREL Subcontract No. ACG-5-15356-01 (21 September 1995).

This work extends prior work performed for NREL to analyze ethanol's value for the entire U.S. petroleum refining sector, as described in two reports. The first of the two reports, *The Refining Value of Ethanol as Gasoline Blendstock and Etherification Feedstock* (18 July 1995), was prepared under Subcontract No. AAW-4-14125-01. The second report, *Effects of the 1 psi Waiver on the Refining Value of Ethanol as Gasoline Blendstock and Etherification Feedstock* (14 November 1995), was prepared in Task 1 of this subcontract.

The prior work: (1) explored the technical determinants of ethanol's refining value as a gasoline blendstock and as an etherification feedstock; (2) developed aggregate demand functions for fuel-grade ethanol in the U.S. refining sector, for the year 2010; and (3) explored the effects on aggregate demand curves of maintaining the current 1 psi RVP waiver for ethanol-blended gasoline. The estimated demand functions corresponded to various crude oil and natural gas prices projected for 2010 in DoE's *1995 Annual Energy Outlook* and reflected assumptions regarding future refining technology, refining economics, and public policies bearing on gasoline quality and composition.

1.0 Objective of this Study

This analysis develops aggregate demand functions for fuel-grade ethanol used as etherification feedstock for ETBE blended in California RFG:

- separately for the summer and winter seasons;
- for two alternative methanol prices, by season;
- for three alternative MTBE prices, by season; and
- under the assumption that the California Phase 2 RFG standards remain in force.

The results and organization of this analysis are different from previous studies of the entire U.S. refining sector, because California presents a special case. Its Phase 2 RFG standards are more stringent than the federal Phase 2 RFG standards and all gasoline sold in California (and the bulk of gasoline produced by California refineries) must meet those standards.

Our analysis indicates that the value of ethanol as feedstock to ETBE blended in California RFG is a function primarily of the price of methanol, the price of MTBE, and the season. As etherification feedstock, ethanol: (1) is worth more than methanol in the summer and about the same in the winter; (2) declines in value with the price of methanol; and (3) increases in value during the summer with the price of MTBE.

2.0 Overview of California

Exhibit 1 shows California's stringent Phase 2 RFG standards. The standards go into effect in March of 1996; all gasoline consumed in California (about one million bbl/d) must meet the standards.

There are 24 operating refineries in California, with an aggregate crude distillation capacity of about 2 million bbl/d -- about 12% of total U.S. crude distillation capacity. By now, refineries that have chosen to produce California RFG have installed the process capacity necessary to do so. At least nine of the California refineries either produce no gasoline or are not capable of producing California RFG. Exhibit 2 shows current process capacities for each refinery in California, along with aggregate refining capacity.

Exhibit 3 shows the volume, quality, and source of crude oil processed by California refineries in 1994. Domestic crude oil accounted for over 90% of crude oil use. Over time, production of both Alaskan and California crude oils is expected to decline. California refiners no doubt will replace domestic crude oil with foreign crude whose properties are consistent with the refineries' processing capabilities. Consequently, for purposes of this analysis, we assumed no change from the current crude oil slate.

California has little capacity for production of either ethanol or ethers. Ether capacity is about 12 M bbl/d -- far less than the 100 M bbl/d (or so) of oxygenates needed to produce California RFG.[1] Thus, California refineries must rely on oxygenates supplied by merchant ether plants located in the U.S. Gulf Coast or foreign countries.

In 1995, California refineries blended about 70 M bbl/d of MTBE in federal RFG and oxygenated gasoline. About 40% of the MTBE (28 M bbl/d) was imported from foreign countries.[2] About 15% was produced by in-state refinery-based MTBE plants. The remaining 45% (about 30 to 35 M bbl/d) was imported from PADD 3. Data are not yet available on the

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[1] The California "predictive model" allows gasoline with no oxygen content to be certified as California Phase 2 RFG. However, the more stringent properties required for a "no-oxygen RFG," along with economics that favors blending ethers in California RFG, suggest that most California refineries will blend oxygenates within the 1.8 wt% to 2.2 wt% oxygen content limits.

[2] MTBE was imported from Canada, Saudi Arabia, and Venezuela -- relative import shares were about 40%, 40%, and 20% , respectively.

volumes and sources of MTBE supply to the all California RFG market, though we expect imports of foreign-produced MTBE to increase.

For the purpose of this analysis, we assumed all oxygenates imported by California refineries are supplied by Gulf Coast merchant plants. Such plants could shift from MTBE to ETBE, depending on the demands of California refineries and the relative prices of etherification feedstocks -- methanol and ethanol. However, to the extent that California refineries rely on MTBE supplied by foreign-based merchant plants, the demand curves for ethanol developed in this analysis will overstate the market value of ethanol at large volumes. Foreign-based suppliers (who are not candidates for conversion to ETBE) would continue supplying MTBE to the California market until its price dropped sufficiently to make other oxygenate markets more attractive. This would require reductions in the price of ethanol so that ETBE produced by PADD 3 merchant plants could be priced low enough to displace foreign-produced MTBE.

3.0 Factors Affecting the Value of Ethanol as Etherification Feedstock

The primary factors affecting the value of ethanol as etherification feedstock for ETBE blended in California RFG are:

- the price of methanol;
- the market price of competing oxygenates, i.e., MTBE; and
- the season -- because RVP limits vary seasonally.

The price of crude oil is the most important determinant of ethanol's refining value when blended directly in conventional gasoline. But the value of ethanol as a feedstock for ETBE blended in RFG is relatively insensitive to changes in crude oil prices.[3] Because all gasoline sold in California must be California RFG, we assessed only one crude oil price scenario in this analysis -- the AEO mid-price scenario

4.0 Seasonal Use of Ethanol

The RVP of California Phase 2 summer RFG will be about 6.5 to 7.0 psi, so that RBOB (refinery blendstocks for oxygenate blending) for ethanol blending must have an RVP of 5.5 to 6.0 psi. This, in combination with other stringent limits on gasoline properties (met more easily with MTBE or ETBE because of their greater dilution effects) make it technically infeasible or

[3] For example, an increase in crude oil prices of about 20% (holding the price of MTBE and methanol constant)reduces the summer value of ethanol by about 2.5%. The small change in ethanol's value as an etherification feedstock results from the effect an increase in crude oil prices would have on the price of butane -- presumably butane prices would increase. This adversely affects the economics of ETBE production, because relatively more butane is used per barrel of ETBE than MTBE. Reductions in crude oil prices and the price of butane correspondingly increase the value of ethanol.

prohibitively expensive to blend ethanol in RFG in the summer. Direct blending of ethanol in the summer is unlikely to be practiced.

Ethanol could more readily be used during the winter, but seasonal switching of ethanol in RFG would entail additional distribution costs and require additional investments in process capacity. Hence, we assume in this analysis that the use of ethers in California RFG is constant across seasons and that the stock of refining process capacity is optimized for constant use across seasons.

5.0 Methodology and Scenarios

We employed our generalized refinery modeling system (ARMS) to assess the maximum value of ethanol as etherification feedstock for ETBE blended in California RFG. The ARMS runs estimate the highest price that merchant ether producers in the Gulf Coast could pay for fuel-grade ethanol, at specified volumes, and still remain competitive selling ETBE to California refineries.

Two "equilibrium conditions" must be met to establish this "maximum price" for ethanol as an etherification feedstock for ETBE. First, the price of ETBE must equal its refining value to California refiners, which is strongly influenced by the price of MTBE. (If ETBE's price is higher than its refining value, California refiners would not be interested in buying ETBE; at a price lower than its refining value, more ETBE could be sold or more profits could be made by raising its price.) Second, the price of ethanol must be such that merchant ether producers find it as profitable to produce ETBE as MTBE. If not, producers will shift production to the more profitable ether.

In this analysis we:

- estimated the value of ethanol in both the summer and winter seasons at alternative volumes of ethanol use;
- assessed the effects on the refining value of ETBE of season and volume of use; and
- assessed the effects on the value of ethanol of variations in the price of methanol and of MTBE, by season.

Throughout the analysis, we used the AEO mid-range crude oil and natural gas price forecast for the year 2010: $24.12/bbl for crude oil and $3.39/mcf for natural gas price. We allowed ARMS to optimize refining process capacity to produce 100% RFG using MTBE. We use this optimized process capacity as the "existing" capacity in 2010 for subsequent ARMS runs. (Our analysis indicates that reported process capacity for California refineries, with the addition of certain operations generally not reported in capacity surveys, is sufficient to produce all of the required volume of California RFG.)

6.0 Model Inputs -- Boundary Conditions

The data used to set the boundary conditions for the various ARMS runs (crude oil and other refinery inputs, product outputs, and refining capacity) are shown in Exhibits 4 through 8.

- Exhibit 4 shows the prices for key refinery inputs and refined outputs from the AEO mid-price scenario. Prices for propane, butane, iso-butane, methanol, and MTBE are the same as in the 18 July study.

- Exhibit 5 shows the crude oil slate used in the analysis. In each model run, Alaskan North Slope is the "swing crude," i.e., the crude oil whose volume is allowed to vary and whose price corresponds to the AEO world oil price projection.

- Exhibit 6 shows purchased fuel and unfinished oil inputs. We leave butane inputs open (volume optimized at the given price). RVP requirements should eliminate the use of purchased butane in the summer, but permit its use in the winter. We set a minimum iso-butane use of 29 M/bbl/d, based on current use, and allowed up to 10 M bbl/d of additional purchases at a higher price (25¢/bbl more than shown in Exhibit 4).

- Exhibit 7 shows projected refinery outputs for 1996. The projections reflect refinery outputs in 1994 and 1995. If gasoline demand in California grows at the rate projected by the AEO for the entire U.S., the potential volume of ethanol that could be used as etherification feedstock in 2010 would be about 10 percent greater than estimated in this analysis.

- Exhibit 8 shows aggregate baseline process capacities as of January 1996. These estimates reflect data from EIA, the Oil & Gas Journal, and ARMS runs..

7.0 Other Assumptions in ARMS Runs

Other assumptions incorporated in our analysis include:

- The California refining sector can be considered as one aggregate refinery for purposes of estimating ethanol's value as etherification feedstock.

- The long-term price of methanol is a function of the natural gas price and includes a suitable return on invested capital.

- Distillate and resid specifications satisfy existing EPA standards and industry specifications.

- The gasoline grade split is: 21% premium, 18% mid-grade, and 61% regular.

8.0 Results of ARMS Runs

The primary results of our analyses are shown in Exhibits 9 through 12 and are summarized below.

- Up to about 50 M bbl/d of ethanol could be used as etherification feedstock for ETBE blended into California RFG.

- The value of ethanol is relatively insensitive to changes in volume, as indicated in Exhibit 9. Its value is about $5/bbl higher in the summer than in the winter, i.e., its value is higher than methanol's value in the summer and lower in the winter.

- The value of ETBE is higher than MTBE in the summer and lower in the winter, as Exhibit 10 indicates. ETBE's higher octane and lower RVP (relative to MTBE) is less valuable in winter, and refiners would prefer to minimize oxygenate use in the winter (the higher RVP limit allows them more blending flexibility in the winter.) Moreover, ETBE's lower oxygen content (relative to MTBE) requires that refiners use more of it to meet the 1.8 wt% minimum oxygen content limit, thereby reducing its value. The change in the value of ETBE to refiners between seasons is the reason ethanol's value varies seasonally.

- Reductions in the price of methanol significantly reduce the market value of ethanol, as Exhibit 11 shows. The implication is that the market price of methanol will be the primary determinant of the value of ethanol as etherification feedstock.

- Increases in the market price of MTBE increase the market value of ethanol *during the summer season*, as Exhibit 12 shows. During the winter season, the value of ethanol is insensitive to the market price of MTBE.

In summary, the value of ethanol as feedstock to ETBE blended in California RFG is a function primarily of the price of methanol, the price of MTBE, and the season. As etherification feedstock, ethanol: (1) is worth more than methanol in the summer and about the same in the winter; (2) declines in value with the price of methanol; and (3) increases in value during the summer with the price of MTBE.

References

Advanced Resources International/MathPro Inc., "Analysis of the Effects on Japanese and California Refineries of Removing the Ban on Exporting Alaskan Crude Oil," submitted to U.S. Department of Energy, April 29, 1994.

California Air Resources Board, "California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model," April 20, 1995.

Energy Information Administration, *Annual Energy Outlook, 1995, with Projections to 2010*, January 1995.

Energy Information Administration, *Petroleum Marketing Monthly*, 1995 issues.

Energy Information Administration, *Petroleum Supply Annual, 1993*, June 1994.

Energy Information Administration, *Petroleum Supply Annual, 1993*, May 1995.

Energy Information Administration, *Petroleum Supply Monthly*, 1995 issues.

Information Resources, Inc., *Transportation Fuel Reformulation: 1995 - 2005*, November 1994.

MathPro, Inc., "Effects of the 1 psi RVP Waiver on the Refining Value of Ethanol as Gasoline Blendstock and Etherification Feedstock," submitted to National Renewable Energy Laboratory, November 14, 1995.

MathPro, Inc., "The Refining Value of Ethanol as Gasoline Blendstock and Etherification Feedstock," submitted to National Renewable Energy Laboratory, July, 18, 1995.

Williamson, Michelle, Ed., "Worldwide Refining Survey," *Oil & Gas Journal*, Dec. 18, 1995.

Exhibit 1: Standards for California Phase 2 RFG

Property	Limits		
	Flat	Averaging	Cap
RVP (psi)	7.0	none	7.0
Oxygen (wt %)			
minimum	1.8	none	1.8
maximum	2.2		2.2
Aromatics (vol %)	25.0	22.0	30.0
Benzene (vol %)	1.00	0.80	1.20
Olefins (vol %)	6.0	4.0	10.0
Sulfur (ppm)	40	30	80
T50 (°F)	210	200	220
T90 (°F)	300	290	330

Source: CARB, 1995.

Exhibit 2

California Refining Capacity -- 1995

(barrels per stream day)

Location/Refinery	Crude Dist.	Vacuum Dist.	Thermal Cracking: Delayed Coking	Thermal Cracking: Fluid Coking	Thermal Cracking: Visb.	Thermal Cracking: Other/ Gas Oil	Cat Crack	Cat. Reforming: Low	Cat. Reforming: High	Cat. Hydro Crack.	Catalytic Hydrotreating: Heavy Gas Oil	Catalytic Hydrotreating: Naphtha Feeds	Catalytic Hydrotreating: Dist.	Catalytic Hydrotreating: Other/ Resid.	Other Processes: Solv. Deasph.	Other Processes: Alky-lates	Other Processes: Arom.	Other Processes: Isomers: Butane	Other Processes: Isomers: Pen./Hex.	Other Processes: Cat. Polm.	Other Processes: Dimer-sol	Other Processes: Oxygenates: MTBE	Other Processes: Oxygenates: TAME	Miscellaneous: Lubes	Miscellaneous: H2 MMcf/d	Miscellaneous: Coke	Miscellaneous: Sulfur ST/d	Miscellaneous: Asphalt
o Products Co. - Los Angeles	242,000	115,500	58,000				93,000		50,000	38,000	85,000	39,000	17,000	15,700		13,000				3,000		2,500			75	11,500	290	
vron USA, Inc. - El Segundo	268,000	122,000	66,000				69,000		40,000	49,000	75,000	56,000	74,000			8,400			20,000			2,000			130	17,000	700	
vron USA, Inc. - Richmond	345,000	115,000					67,000		82,000	95,000	60,000	35,000	110,000	18,000	50,000	8,000			16,000	1,000				15,300	185		440	
on Co. USA - Benicia	132,000	67,000		27,500			69,000		34,900	32,000	37,000	49,000	35,000	17,000		14,000				1,000		4,000			104	5,500	304	
tway Refining Co. - Benicia*	9,000	5,250																										3,250
tway Refining Co. - Wilmington*	6,000	5,700																										3,500
n Oil & Refining Co. - Bakersfield*	23,000								2,800			5,000	7,300															
oil Oil Corp. - Torrance	140,000	101,000	49,500				85,000		35,000	22,000	101,000	23,000	28,000			22,000									125	14,500	441	
fic Refining Co. - Hercules	55,000	25,000			11,000				11,200	4,000		11,200																6,000
mount Petroleum Corp. - Paramount	46,500	28,000							11,500			8,000	7,000	21,500														15,000
olmen Fuel & Terminal - Long Beach*	13,000																											
erine Oil Co. - Santa Fe Springs	49,950	36,000	11,000				12,500		9,800	8,000	13,000	19,300	10,500			2,700		1,800							20	3,200	50	
Joaquin Refining Co. Inc - Bakersfield*	27,000	12,000			5,000																			4,000				8,000
l Oil Co. - Martinez	151,100	103,900		22,500			67,000	30,000		32,000	53,000	20,000	22,000	20,000		10,000			15,000		2,200			4,100	107	140	280	15,000
and Refining Corp. - Bakersfield*	17,000							1,250				700	700															
y, Inc. - Oxnard*	3,000																											1,200
co Refining & Marketing - Bakersfield	58,000	31,500	20,000					16,000		17,500	17,000	12,900						700							24	5,500	96	1,000
co Ref. & Mar. - Wilmington	70,000	56,100	68,700				32,300		29,800	28,400	28,900	21,900	14,700	12,000		6,300									69	10,000	260	
o Corp. - Martinez (Avon)	160,000	128,000		48,000			70,000	23,000	20,000	53,000	63,000	25,000	30,800			16,000						2,000			80	3,500	200	
mar Refining - Wilmington	70,000	40,000	23,000				56,000	14,500			45,000	21,000				10,500		8,000								7,440	148	
cal Corp. - Arroyo Grande*	44,000	32,000	23,200																							7,000	107	
cal Corp. - Rodeo (San Francisco)	77,000	42,100	23,700						34,000	34,000		23,000	10,000	14,500					7,400					4,700	65	6,337	392	
cal Corp. - Wilmington	125,000	71,000	32,000				47,000	37,000	17,000	25,000	50,000	36,500	30,000			18,500									76	11,500	680	
o Corp. - Oildale*	0	30,000												900										6,000				4,000
l	2,035,550	1,127,050	395,100	96,000	16,000	0	647,800	121,750	357,100	419,900	626,900	437,700	395,200	119,600	50,000	121,400	0	10,200	58,400	7,000	2,200	11,500	0	34,300	1,060	101,117	4,380	56,950

efineries unlikely to produce California RFG.

Exhibit 3: Crude Oil Inputs to California Refineries, 1994

Source	Volume		Sulfur	Gravity	
	M bbl	M bbl/d	(wt%)	API	Specific
DOMESTIC:	**622,184**	**1,705**	**1.28**	**23.3**	**0.914**
ALASKA	297,475	815	1.11	27.5	0.890
CALIFORNIA	324,709	890	1.42	19.7	0.936
FOREIGN:	**45,766**	**125**	**1.32**	**28.6**	**0.884**
ARGENTINA	1,211	3	0.19	31.7	0.867
CHILE	1,566	4	1.05	32.9	0.861
CHINA, PEOPLE'S REP	8,159	22	0.13	32.4	0.863
COLOMBIA	370	1	0.91	29.3	0.880
ECUADOR	12,910	35	1.10	28.0	0.887
INDONESIA	1,900	5	0.14	27.1	0.892
KUWAIT	8,235	23	2.50	31.5	0.868
OMAN	5,209	14	1.01	33.9	0.855
SAUDI ARABIA	1,081	3	1.20	32.5	0.863
VENEZUELA	5,125	14	2.87	13.8	0.974
TOTAL:	**667,950**	**1,830**	**1.28**	**23.7**	**0.912**

Sources:

Derived from Detailed DOE Crude Oil Import Data, 1994; Table A5, ARI/MathPro, 1994; and Table 16, EIA-PSA, 1994.

Exhibit 4

Selected Prices for Refinery Inputs and Outputs for AEO Mid Price Scenario for 2010

Input/Output	Price	Source
World Oil (average refiner acquisition cost)	24.12	1
Wellhead Natural Gas (1993 $/mcf)	3.39	1
Methanol: full cost	28.35	2
variable cost	20.79	2
Propane	18.33	3
Isobutane	21.71	3
Butane	20.50	3
U.S. Merchant MTBE: full cost	46.42	4
variable cost	32.97	4
assumed price	43.53	5
Residual Oil: low sulfur	24.60	6
high sulfur	20.10	6

Sources:

1. Table C-11and C-14, Annual Energy Outlook, 1995, EIA, January 1995
2. Based on natural gas price & near term economics for Gulf Coast in Hahn, "Economics of Methanol," Economics Bulletin No. 1, Auto/Oil Research Program, January 1992.
3. Derived based on crude oil prices.
4. Derived based on ARMS data base.
5. 18 July Report to NREL.
6. ARMS baseline model run.

Exhibit 5

Aggregate Crude Oil Inputs to California Refineries, 1994
(M Bbl/day)

Crude Oil	Volume	% Sulfur	Gravity API	Gravity Specific
Domestic:				
Alaskan North Slope	815	1.11%	27.5	0.890
Composite California Crude	890	1.43%	19.7	0.936
Imports:				
Composite Foreign Crude	125	1.32%	28.7	0.883

Sources: Derived from Exhibit 2; Table 6 of 29 April Report to DOE, and MathPro assay data.

Exhibit 6

Other Inputs to California Refineries, 1996 (Projected
(M Bbl/day)

Inputs	1996
Purchased Fuel	
Natural Gas (M FOEB/day)	29
Residual Oil	-
Unfinished Oils (M Bbl/day)	
Isobutane	29
Normal Butane	-
Resid/Gas Oils	12
Natural Gasoline	33

Sources: Derived from:
Table 25, EIA -PSM, Dec. 1995; and
Table A4, ARI/MathPro, 1994.

Exhibit 7

Product Slate of California Refineries: 1996 (Projected)

(M Bbl/day)

Refined Product	Volume
LPGs:	
Propane	open
Propylene	open
Normal Butane/Butylene	open
Isobutane	open
Aviation Gasoline	5
Gasoline Blending Components	-
Gasoline	976
Jet Fuel (naphtha)	-
Jet Fuel (kerosene)	263
Distillate:	
Low Sulfur Diesel Fuel	201
#2 Fuel Oil	81
Petrochemical Feedstocks:	
Aromatics	-
Naphtha	-
Gas Oils	8
Residual Oil:	
.31% sulfur or less	19
.31% to 1% sulfur	16
1% sulfur & greater	123
Road Oil and Asphalt	34
Lubes and waxes	22
Coke	103
Total:	1,851

Sources:

Table 7, ARI/MathPro, 1994.

Table 25, EIA, PSM, Dec. 1995.

Exhibit 8

Estimated Process Unit Capacities of California Refineries, 1996

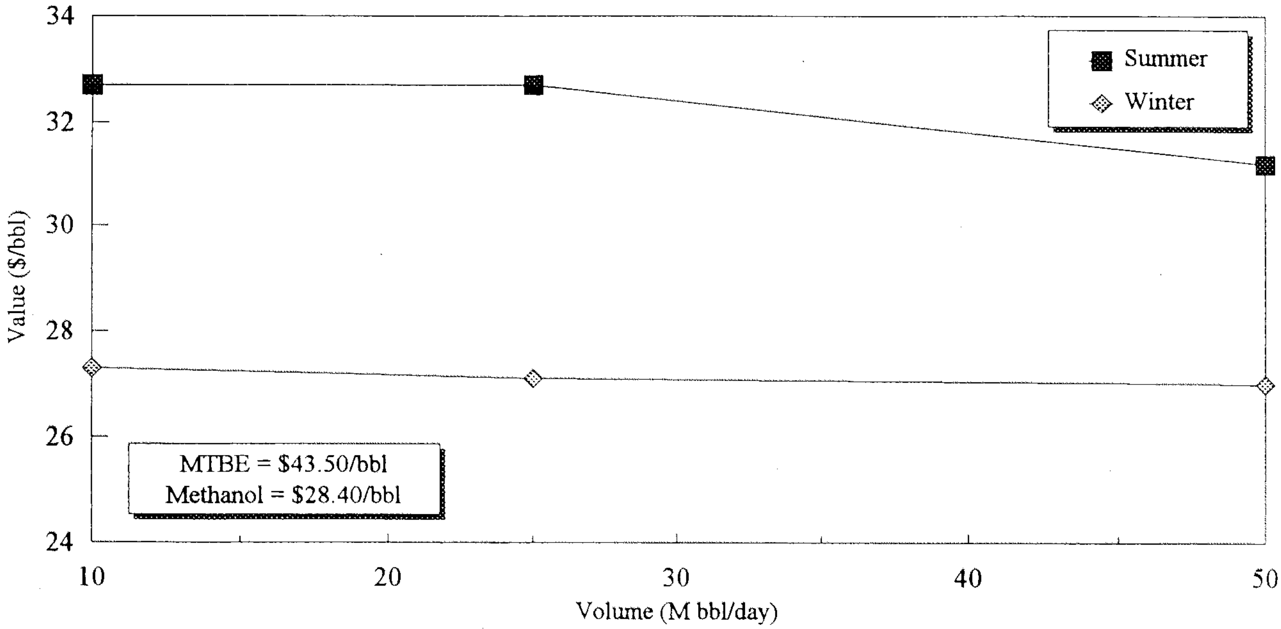
(M Bbl/stream day)

Process	Capacity
Crude Distillation	2,036
Vacuum Distillation	1,127
Alkylation: C4	150
C5	
Aromatics Recovery	
Benzene Extraction	
Butane Isomerization	10
Butene Isomerization	
Catalytic Polymerization	7
Coking: Delayed	395
Fluid	96
Flexi	
Debutanization	143
Desulfurization:	
Distillate	395
FCC Feed	627
Naphtha	438
Resid	120
Dimersol	2
Ether Production:	
MTBE/ETBE	12
TAME/TAEE	
DIPE	
EIPE	
Fluid Cat Cracking	648
Hydrogen Production	54
Hydrocracking:	
Distillate Feeds	168
Gas Oil Feeds	252
Lube & Wax Production	34
Pen/Hex Isomerization:	
Once Thru	
Total Recycle	58
Reforming: 150 psi	122
150-350 psi	357
Resid Cat Cracking	
Solvent Deasphalting	50
Sulfur Recovery	4
Visbreaking	16

Note: Italics denote commercially available new processes for which little or no new capacity was on-line in 1994

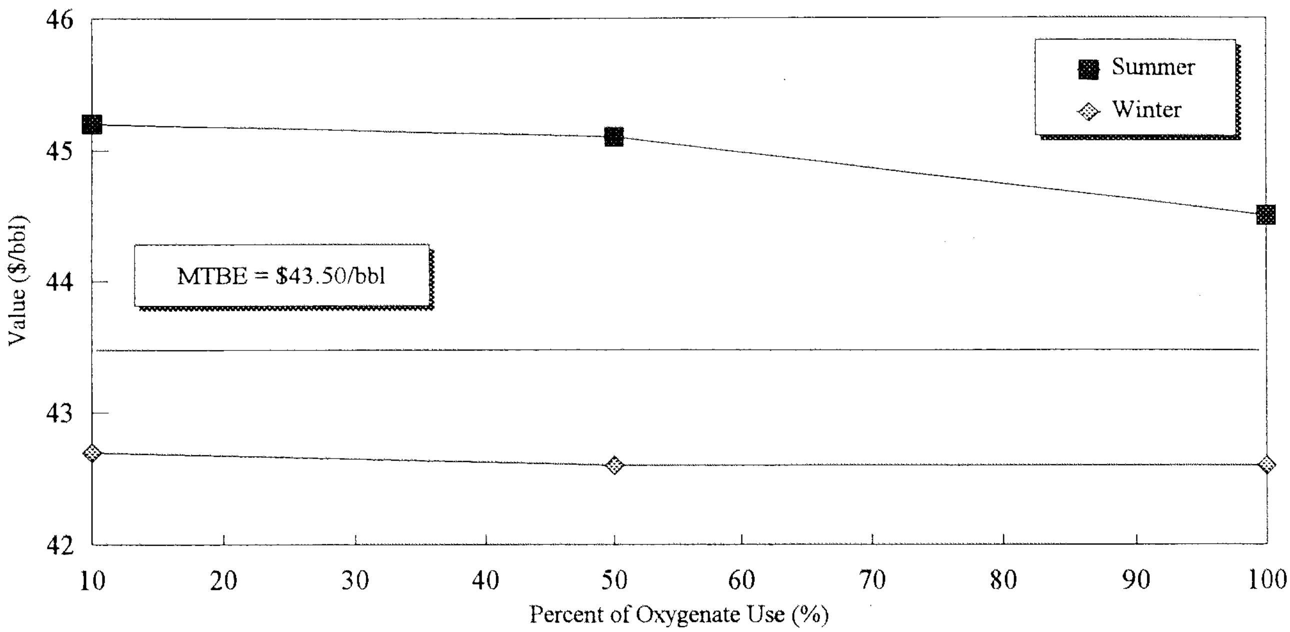
Sources: Exhibit 1 and ARMS runs.

Exhibit 9: Value of Ethanol as Feedstock for ETBE Blended in California RFG, by Season



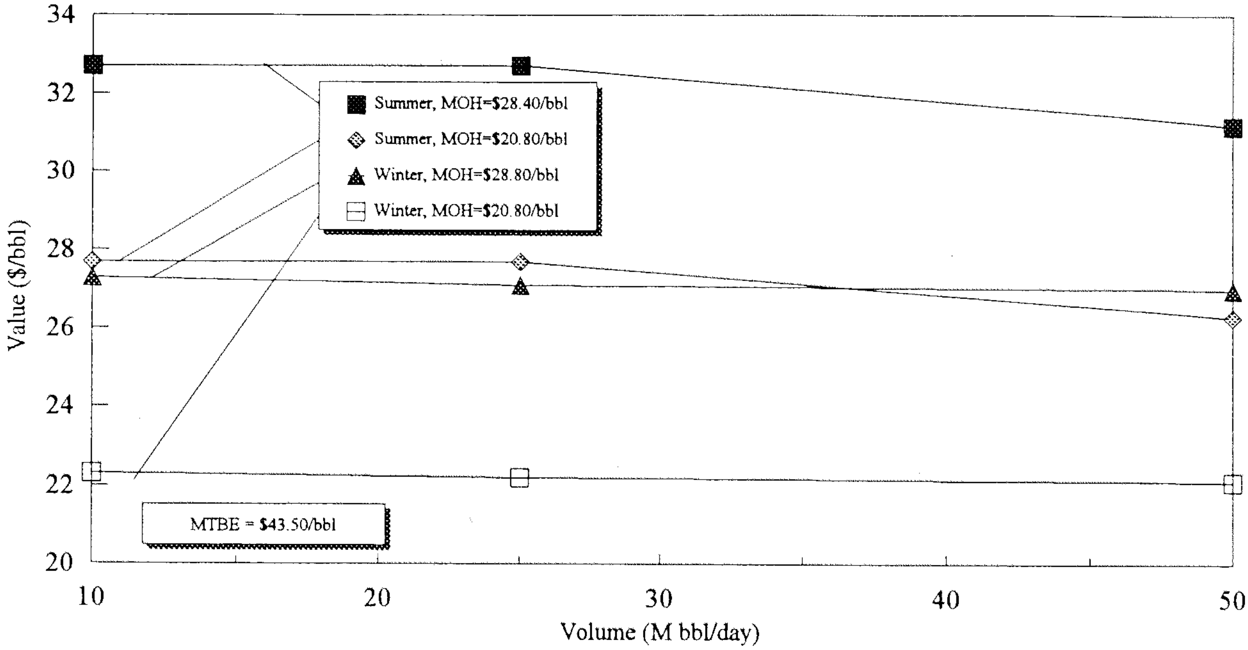
Volume of Ethanol (bbl/d)	Season	
	Summer	Winter
10	32.70	27.30
25	32.70	27.10
50	31.20	27.00

Exhibit 10: Value of ETBE Blended in California RFG, by Season



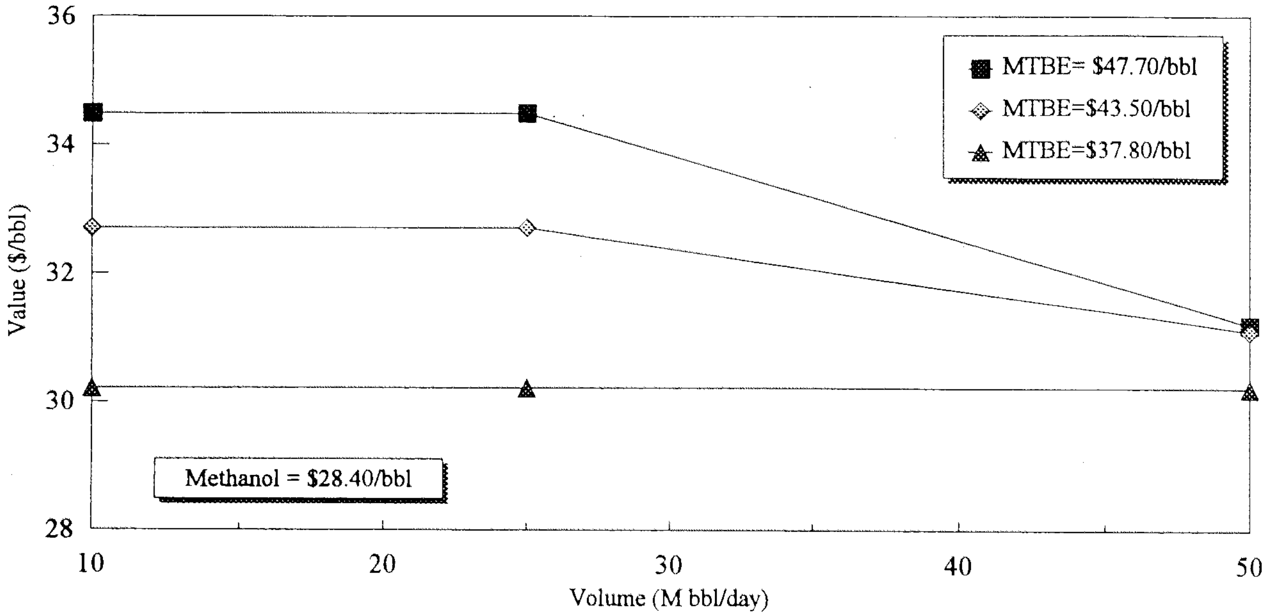
Percent of Oxygenate Use	Season	
	Summer	Winter
10	45.20	42.70
50	45.10	42.60
100	44.50	42.60

Exhibit 11: Value of Ethanol as Feedstock for ETBE Blended in California RFG, by Season and Price of Methanol



Volume of Ethanol (bbl/d)	Summer		Winter	
	moh=28.40	moh=20.80	moh=28.40	moh=20.80
10	32.70	27.70	27.30	22.30
25	32.70	27.70	27.10	22.20
50	31.20	26.30	27.00	22.10

Exhibit 12: Value of Ethanol as Feedstock for ETBE Blended in California RFG:
Summer Season, by MTBE Price



Volume of Ethanol (bbl/d)	MTBE Price ($/bbl)		
	47.70	43.50	37.80
10	34.50	32.70	30.20
25	34.50	32.70	30.20
50	31.20	31.10	30.20